Clinical Update

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Clinical application of electronic apex locators with an emphasis on the Root ZX®

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Introduction

Electronic apex locators (EALs) have aided root canal working length determination for over 40 years (1). Their erratic clinical behavior and interpretation can be a source of frustration for some dental providers. The purpose of this *Clinical Update* is to provide an understanding of apex locator function, discuss clinically relevant issues, and offer guidelines for use and trouble-shooting. Also, implications for use on patients with cardiac pacemakers will be discussed.

Background

Ideally, the endpoint of endodontic instrumentation and obturation is at the minor apical constriction near the cementodentinal junction (2). Beyond this anatomical landmark is the periodontium. In a 1941 dog study, Suzuki determined the electrical resistance between an instrument in the root canal and an electrode applied to the mucous membrane to be constant (3). Later, Sunada found the resistance value between the root canal and the oral mucosa in humans was constant at 6.5 KΩ (1). First-generation EALs merely used direct current and the known constant resistance as a basis for working length determination. Their major drawback was the need for the canal to be thoroughly debrided and dry. Later devices became more sophisticated, allowing some fluid in the canal. Second-generation EALs used a single frequency alternating current (AC) and measured changes in impedance for a more reliable measurement under more normal clinical conditions. The major disadvantage encountered with second-generation EALs was the need for a relatively large insulated probe to be used in the canal instead of a small, uninsulated endodontic file. In an effort to improve the accuracy and reliability of canal length determination under normal clinical conditions, third-generation EALs evolved that employed multiple AC frequencies that monitor changes in impedance. Third-generation EALs enjoys widespread use today. A more detailed explanation of each type of apex locator (Resistance type, Impedance type and Frequency Dependent type), can be found in reviews by MacDonald (4), Rhode and Hutter (5) and Kobayashi (6).

Does the pulpal diagnosis affect EAL measurements?

EALs should be used in all non-surgical endodontic cases. The different pulpal diagnoses were shown not to adversely affect the consistency of electronic length determination. Third-generation EALs have shown functional reliability with no statistically significant difference in measurements between teeth with necrotic or vital pulpal diagnoses (7).

Do EALs reduce radiation exposure?

In a study examining whether the use of an EAL locator could reduce X-ray exposure, it was concluded that EALs could potentially reduce the number of radiographs required for working length determination by aiding in initial file placement. The combination of multiple modalities in working length determination is more accurate than using radiographs alone (8). Radiographs or digital images remain the standard of care but EALs are a critical adjunct in endodontic therapy.

Electronic apex locator and cardiac pacemakers

Many items in the dental office (pulp testers, electrosurgery and EALs) could potentially interfere with cardiac pacemakers. Recently, a study was performed testing five different EALs for cardiac pacemaker irregularity as detected on oscilloscope and telemetry units. The EALs were directly wired to the pacemakers while the oscilloscope and telemetry units monitored for any sign of pacing abnormality. The Root ZX® caused no interference with pacemaker activity while the Justwo® and the EIE® apex locators both recorded the absence of two beats. The Neosono® showed five missing beats and the Bingo-1020® produced an irregular pace recording. The authors concluded that the results suggest that EALs can be used safely in pacemaker patients as most modern pacemakers are shielded to block outside electromagnetic interference and that direct wiring of the apex locator to the pacemaker does not occur clinically (9). However, manufacturers still warn of EAL use in cardiac pacemaker patients (10). An appropriate consult with the patient's cardiologist is ***mandatory***.

What does the Root ZX® measure? (See Figure 1)

The meter display of the Root ZX® is a graphic representation of a 3-2-1-Apex "count-down" as the file advances toward the apex. The operation instruction indicates that the Root ZX® unit is capable of registering the apical constriction when the meter reads "0.5." However, several studies have shown better reliability when readings are taken at the "Apex" (11, 12). In a 1996 article by Shabahang et al, the "0.5" reading was tested as the indicator of working length. After the teeth were extracted with the file cemented in place at the measured apical constriction, 8 of 26 showed file tips extending beyond the apical foramen and another 9 file tips were at the apical foramen. The study reports a 96.2% accuracy in locating the minor constriction ±0.5mm, but actually 17 of 26 files were at or beyond the major foramen (11). In a study by Ounsi and Naaman, a comparison was made between Root ZX® readings of "0.5" and "Apex." The study concluded that the Root ZX® unit should be used to detect the major foramen only and will produce an accuracy of 85% ±0.5mm (12). The clinical impact of these two studies (11, 12) is that maximum accuracy with the Root ZX® is obtained by advancing the file to the "Apex" reading, subtracting 1mm and then verifying the working length with a radiograph.

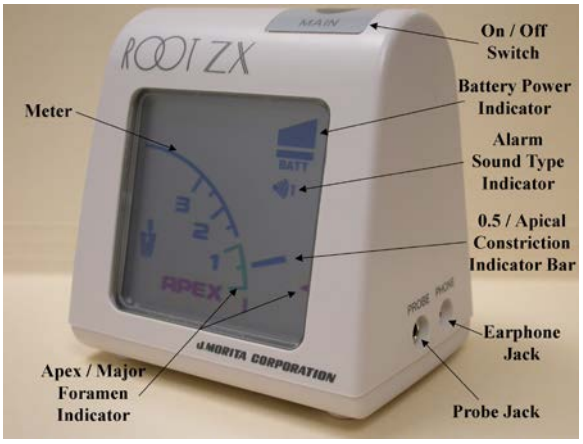

Figure 1 Root ZX® Features (Photo: G. Engel)

Since the apex locator can detect the periodontal apical tissues as indicated by reaching the "Apex", it can also be used adjunctively to detect various perforations. Furcation perforations may be detected if "Apex" is registered immediately upon file insertion into a would-be canal. Strip perforations can be detected and their position measured when "Apex" is reached well short of the estimated working length. Apical perforations may be detected when a sudden change in working length is noted during working length reverification. Once an apical perforation occurs, the "Apex" may register at a location that was previously short of the initial greater foramen "Apex" reading. Another use for an EAL is post perforation detection (10).

Can the Root ZX® be used in large canals or immature teeth?

In teeth with large canals (due to incomplete root formation or aggressive endodontic flaring), it was not necessary to match the canal diameter with a corresponding file. A small file is just as likely to find the apical constriction as a large file in wide diameter canals. In that same study, the Root ZX® identified the apically constricted area of the canal even in the absence of an anatomic apical constriction (13). In canals with simulated apical root resorption, Goldberg et al concluded that the Root ZX® can be used to

accurately determine the working length as "Apex" even in the absence of an apical constriction (14).

Does canal preparation and irrigation affect Root ZX® measurements?

After leak-free rubber dam isolation and straight-line access preparation, the canals should be preflared and irrigated. Canal preflaring can be accomplished with either Gates Glidden burs or nickel titanium orifice openers. The Root ZX® was shown to more consistently reach the apical foramen in canals that were preflared versus canals that were not (15). During canal preparation, various irrigants may be used. Jenkins et al indicated that the Root ZX® reliably measured the canal lengths with virtually no difference in length determination as a function of the seven irrigants tested (2% lidocaine with 1:100,00 epinephrine, 5.25% sodium hypochlorite, RC Prep, liquid EDTA, 3% hydrogen peroxide and Peridex) (16). It is important to dry and clean the pulp chamber of any fluid and debris before using the Root ZX®. The canals may contain irrigation fluid or they may be dried. Any fluid that remains in the pulp chamber may contact soft tissue or a metallic restoration resulting in an instant and erroneous "Apex" reading.

Recommended Clinical Procedures For The Root ZX® (See Figure 1)

The Root ZX® unit requires an initial self-calibration period prior to clinical function. Automatic self-calibration is accomplished by turning on the unit ***before*** plugging in the probe. Automatic calibration takes only a few seconds and a flashing indicator bar will appear at the "0.5" level when calibration is complete. The probe and contrary electrode attachment (lip clip) can be connected to the Probe Jack once the flashing indicator bar appears. The clinical technique of working length determination is to advance the file until the unit reads "Apex" at which point the audible alarm changes from a beep to a full tone. Next, carefully withdraw then insert the file repeatedly until the meter can reproducibly show the file passing through the greater foramen ("Apex"). The working length is then determined by subtracting 1mm from the length measured when the meter flashes the first bar at the "Apex" and the sound first changes from a beep to a full tone. A radiograph/digital image should be exposed with small diameter files in the tooth at the electronically determined working length for verification. Although electronic apex locators were shown to be slightly more reliable than radiographs (17), there is the potential for inconsistency in electronic measurement and radiographic confirmation of any electronically measured working length is highly recommended (7,10-13,18). Please refer to Table 1 for troubleshooting.

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Troubleshooting

Problem	Reason	Solution
No Reading	1. Canal may be obstructed by dentinal shavings 2. No contact with the lip-clip 3. Large canal while using a small file 4. File holder may have CSR autoclave residue preventing good contact 5. Wire separation in file clip 6. Maxillary teeth: root may be in the sinus cavity 7. Unable to obtain patency 8. Canal is dry	1. Take reading before filing or remove apical debris 2. Wet patient's lip 3. Try a larger file 4. Clean all electrical connections, ensure all electrical connections are secure 5. Replace file clip lead 6. Try a larger file 7. Patency not always obtainable in all canals 8. Add some irrigation to canal
Instant "Apex"	1. Wet or moist chamber 2. Debris, metal shavings or pulp in the chamber 3. Proximal decay 4. File or irrigation fluid in tooth contacts a metallic restoration 5. The area is not really a canal, but a furcal perforation 6. Large canal or incomplete apex	1. Dry chamber, ensure saliva-free isolation 2. Remove debris, metal shavings and pulp tissue from the chamber 3. Remove decay and place a temporary restoration if there is communication with the periodontium 4. Reduce the level of irrigation below height of metallic restoration 5. Repair immediately 6. Slightly dry the canal and attempt again, allow time for Root ZX® to recalibrate as file is inserted
Unstable readings when file enters the canal	1. Abundance of tissue in the canal 2. Small file in large canal / excessive flaring 3. Excess irrigant in chamber 4. Metallic restoration 5. Large accessory canal	1. Debride the canals more thoroughly 2. Try a snug fitting file 3. Remove any irrigant from the chamber 4. Avoid any contact with metallic restoration 5. Verify radiographically
Reading stops at 2-3mm mark and file will not advance	1. Sharp turn in the canal near the apex 2. Canal filed before reading and is blocking the apical area 3. Weine type II canal configuration	1. Navigate file to the apex (bend tip of file ~45º) 2. Clean debris from apical area 3. Place file in the long canal at "Apex" and advance the file in the short canal until it contacts the other file

Table 1: Information taken from Root ZX Operating Instructions, 1998 and J. Morita website http:// www.jmoritausa.com/products/info/Root%20ZX_IFU.htm

Dr. Engel is a second year resident in the Endodontics Department and Dr. McClanahan is the Chairman of the Endodontics Department at the Naval Postgraduate Dental School.

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